PATENT COOPERATION TREATY

Rec'd PCT/PTO 27 JAN 2005

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

EISENFÜHR, SPEISER & PARTNER
Martinistrasse 24
D-28195 Bremen
ALLEMAGNE

EISENFÜHR, SPEISER & PARTNER
EINGEGANGEN/RECEIVED
24. Nov. 2004
BREMEN
FBI ST 04.12.20 mll

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT
(PCT Rule 71.1)

Date of mailing *(day/month/year)*	23.11.2004
Applicant's or agent's file reference 663871 MA 7549-01WO	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/JP 03/09648	30.07.2003	31.07.2002

Applicant
MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD. et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

The applicant's attention is drawn to Article 33(5), which provides that the criteria of novelty, inventive step and industrial applicability described in Article 33(2) to (4) merely serve the purposes of international preliminary examination and that "any Contracting State may apply additional or different criteria for the purposes of deciding whether, in that State, the claimed inventions is patentable or not" (see also Article 27(5)). Such additional criteria may relate, for example, to exemptions from patentability, requirements for enabling disclosure, clarity and support for the claims.

Name and mailing address of the international preliminary examining authority:	Authorized Officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Weman, E Tel. +49 89 2399-7961

ATTACHMENT "G"

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 663871	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/JP 03/09648	International filing date *(day/month/year)* 30.07.2003	Priority date *(day/month/year)* 31.07.2002
International Patent Classification (IPC) or both national classification and IPC B23K1/00		
Applicant MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD. et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 7 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 19 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the opinion
   - II ☐ Priority
   - III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☒ Lack of unity of invention
   - V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
24.02.2004	23.11.2004
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized Officer Helot, H Telephone No. +49 89 2399-2287

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/JP 03/09648

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:

Description, Pages

1-93 as originally filed

Claims, Numbers

1-40 received on 04.11.2004 with letter of 03.11.2004

Drawings, Sheets

1/17-17/17 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).

   ☐ the language of publication of the international application (under Rule 48.3(b)).

   ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   ☐ contained in the international application in written form.

   ☐ filed together with the international application in computer readable form.

   ☐ furnished subsequently to this Authority in written form.

   ☐ furnished subsequently to this Authority in computer readable form.

   ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:

   ☐ the claims, Nos.:

   ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application,

☒ claims Nos. 11-32,37-39

because:

☒ the said international application, or the said claims Nos. 11-32,37-39 relate to the following subject matter which does not require an international preliminary examination (specify):

see separate sheet

☐ the description, claims or drawings *(indicate particular elements below)* or said claims Nos. are so unclear that no meaningful opinion could be formed *(specify)*:

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

☐ no international search report has been established for the said claims Nos.

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

☐ the written form has not been furnished or does not comply with the Standard.

☐ the computer readable form has not been furnished or does not comply with the Standard.

IV. Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees, the applicant has:

☐ restricted the claims.

☐ paid additional fees.

☐ paid additional fees under protest.

☒ neither restricted nor paid additional fees.

2. ☐ This Authority found that the requirement of unity of invention is not complied with and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is

☐ complied with.

☒ not complied with for the following reasons:

see separate sheet

4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:

☐ all parts.

☒ the parts relating to claims Nos. 11-32,37-39 .

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-10,34-36,40
	No:	Claims	33
Inventive step (IS)	Yes:	Claims	1-10,35,36
	No:	Claims	33,34,40
Industrial applicability (IA)	Yes:	Claims	1-10, 33-36,40
	No:	Claims	

2. Citations and explanations

see separate sheet

An International preliminary examination report has been established to take into account the requirements of Rule 69(2) PCT.

Re Item III

Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

Claims 11-32 and 37-39 have not been examined for the following reasons:
In response to the lack of unity objection raised in Item IV of the written opinion of 13.09.2004, the applicants neither restricted substantially the claims nor indicated on which group of claims the examination report should be directed. Consequently, in accordance with Article 34(3)(c) and Rule 68(5) PCT, the examination is restricted to claims 1-10,33-36 and 40.

Re Item IV

Lack of unity of invention

The method as defined in independent claims 1 and 11 have only the following common features:
A method of thermal analysis calculating a heating characteristic value for at least one point based on a measured temperature of the measuring point as well as heating temperature and heating time at any measuring point of the heating furnace.
These features are known from the US patent 4 927 068 (Naka et al.), which discloses (see claims 1 and 2) the determination of the heat transfer rate, that can be considered as a heating characteristic. This determination is made for a point on a substrate as a function of time, time interval, temperature on a substrate and temperature of the heater.
Thus, the requisite unity of invention (Rule 13.1 PCT) does not exist, since a technical relationship involving one or more of the same or corresponding special technical features in the sense of Rule 13.2 PCT does not exist between claims 1 and 11.
Two groups of claims are distinguished comprising independent claims 1 and 11
Group I: comprising claims 1-10,33-36 and 40
Group II: comprising claims 11-32 and 37-39.

Re Item V

Reasoned statement under Article 35 (2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1 In accordance with Article 34(3)(c) and Rule 68(5) PCT the reasoned statement deals with claims 1-10,33-36 and 40 belonging to the first group of claims.

2 Reference is made to the following document:
D1: US-A-4 927 068.

3 Document D1 is regarded as being the closest prior art to the subject-matter of claim 1.

3.1 Document D1 discloses a method of thermal analysis, wherein the quantity of heat flux at any measuring point of an object at any measuring location of a heating furnace is determined.
The quantity of heat flux can be considered as a heating characteristic.
The quantity of heat flux is calculated by using temperature measured at the measuring point of the object (Tij) and heating temperature (Tw) and heating time (tau) at the measuring location of the heating furnace.
The quantity of heat flux represents physical characteristics of both of the heating furnace and the object to be heated.
Thus, the subject-matter of claim 1 is distinguished from this prior art mainly in that changes of the physical characteristics or defects of the heating furnace are detected by obtaining the value of the heating characteristic periodically and analyzing the variance thereof.
The subject-matter of claim 1 is therefore new (Article 33(2) PCT).

3.2 The problem to be solved by the present invention may be regarded as speeding up the detection of the degradation of the proper heating conditions.
The solution to this problem is considered as involving an inventive step (Article 33(3) PCT) for the following reasons:
In document D1 the heat fluxes on different locations of a substrate are determined without any consideration about their variation in time. The further available prior art does not give any hint for analyzing the variance of a heating characteristic. Thus, the subject-matter of claim 1 involves an inventive step (Article 33(3) PCT).

4 Claims 2-10 are dependent on claim 1 and as such also meet the requirements of the PCT with respect to novelty and inventive step.

5 Present apparatus claim 33 corresponds to the part of method claim 1 which is known from document D1, see above item 3.1. Therefore, the subject-matter of claim 33, is not new (Article 33(2) PCT).

6 The additional features of claim 34 correspond to an usual design option that the

skilled person would carry out in relation with the apparatus of document D1 and therefore does not meet the inventive step requirements of Article 33(3) PCT.

7 The additional features of claims 35 and 36 define the heating characteristic value by specific mathematical relations which are not disclosed in the available prior art and not obvious for the skilled person to combine with the features of claim 33. Thus, the subject-matter of claims 35 and 36 meets the requirements of Article 33 (2) and (3) PCT.

8 The present application does not satisfy the requirements of Article 33(3) PCT because the subject-matter of claim 40 does not involve an inventive step.
With the substitution of cooling to heating, claim 40 defines those features of claim 1 which are disclosed in document D1, see above item 3.1. Thus, the subject-matter of claim 40 is distinguished from the disclosure of document D1 only in that cooling is substituted to heating.
The skilled person is aware that the temperature exchanges involved in document D1 are linear and that the relationships apply also for cooling instead of heating. Thus, the skilled person would apply the teaching of document D1 to a cooling process in the frame of his daily practice.
Consequently, the subject-matter of claim 40 does not involve an inventive step.

Additional Remark

Concerning the independent claims of the non examined group of claims the following is added:
With regard to US patents US-A-6 283 379, US-A-6 206 265, US-A-4 775 776, US-A-5 099 442 or the paper of Morales cited in the search report, the subject-matter of method claims 11,12 and 14 appears to meet the requirements of Article 33(2) and (3) PCT. The same applies to the subject-matter of claims 18 to 20, which are directed to programs, to the subject-matter of claim 32, which is directed to a record medium and to the subject-matter of claims 37 and 38, which refer directly or indirectly to the record medium of claim 32.

Bremen, 3 November 2004

Our Ref.: MA 7549-01WO JOE/JUN/ksc

Applicant: MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.
Serial Number: PCT/JP03/09648

New claims (clear copy)

1. A method of thermal analysis, wherein heating characteristic at any measuring point of an object at any measuring location of a heating furnace is determined as a single invariable by using temperature measured at the measuring point of the object and heating temperature and heating time at the measuring location of the heating furnace, which heating characteristic represents physical characteristics of both of the heating furnace and the object to be heated, wherein changes of said physical characteristics and/or defects of the heating furnace are detected by obtaining said invariable periodically and analyzing variance of said heating characteristic.

2. A method according to claim 1, wherein changes of the physical characteristics and/or defects of a specific heating furnace are detected by obtaining said invariables from a plurality of heating furnaces and comparing said heating characteristics of said plurality of heating furnaces among each other.

3. A method according to claim 1, wherein temperature profile of the object when the object is heated under given heating condition is simulated by using the invariable.

4. A method according to claim 1, wherein appropriate heating condition of the heating furnace for heating the object in accordance with a required temperature profile is determined by using the invariable.

5. A method according to claim 4, wherein appropriate heating condition for each of a plurality of heating sections structured in the heating furnace for heating the object in accordance with a required temperature profile are determined by using the invariable obtained from at least one measuring location for each of the plurality of heating sections.

6. A method according to claim 3, wherein said heating condition comprises either one of heating temperature, heating time, transfer speed of the object in the heating furnace, or blowing speed of heated air for heating the object, or any combination thereof.

7. A method according to claim 1, wherein said heating furnace is either one of reflow furnace, heat treatment furnace, sintering furnace, baking oven, melting furnace, or incinerating equipment.

8. A method according to claim 1, wherein said invariable is an m-value defined by:

$$m = \frac{1}{t} \ln\left[\frac{Ta - Tint}{Ta - Ts}\right]$$

wherein In is natural logarithm, Ta is heating temperature of the measuring location of the heating furnace, Tint is initial temperature of the measuring point of the object at the measuring location, Ts is achieved temperature when the object is heated at the measuring location, and t is heating time at the measuring location.

9. A method according to claim 8, wherein temperature Ts of the object is determined when heating temperature Ta and heating time t of the heating furnace are given, or heating temperature Ta and heating time t are determined when required temperature Ts is given by using said m-values based on a following basic equation for heating:

$Ts=Ta - (Ta-Tint)\, e^{-m \cdot t}$

wherein e in the equation represents the base of natural logarithms.

10. A method according to claim 8, wherein said m-value is adjusted based on a predetermined equation of relationship between the blowing speed of the

heated air and the m-value when the blowing speed of the heated air of the heating furnace is changed.

11. A method of thermal analysis for determining appropriate heating condition for heating an object in a heating furnace in accordance with a required temperature profile corresponding to predetermined required conditions for heating the object, wherein said method comprises steps of:

determining a sample object to be heated and heating condition of the heating furnace;

determining required conditions for heating the object;

heating the sample object, and measuring temperature of at least one measuring point of the sample object at a plurality of measuring locations of said heating furnace;

calculating heating characteristic value for each measuring point at each measuring location based on measured temperature of the measuring point as well as heating temperature and heating time at each measuring location;

modifying the heating condition by changing either one of or both of the heating temperature and the heating time of at least one of the measuring locations;

simulating temperature of each measuring point of the object at each measuring location of the heating furnace under the modified heating condition by using the corresponding heating characteristic values based on a basic equation for heating;

determining that the modified heating condition is appropriate for satisfying the required temperature profile when a temperature profile developed from the simulated temperature meets said required conditions, and

re-modifying the heating condition when the developed temperature profile does not meet said required conditions, and repeating the above procedures until the developed temperature profile meets the required conditions,

wherein said heating characteristic value is an m-value defined by:

$$m = \frac{1}{t} \ln\left[\frac{Ta - Tint}{Ta - Ts}\right]$$

wherein ln is natural logarithm, Ta is heating temperature of the measuring location of the heating furnace, Tint is initial temperature of the measuring point of the object at the measuring location, Ts is achieved temperature when the object is heated at the measuring location, and t is heating time at the measuring location.

12. A method of thermal analysis for determining appropriate heating condition for heating an object in a heating furnace having a plurality of heating sections in accordance with a required temperature profile corresponding to predetermined required conditions for heating the object, wherein said method comprises steps of:

determining a sample object to be heated and heating condition of each heating section of the heating furnace;

determining required conditions for heating the object;

heating the sample object, and measuring temperature of at least one measuring point of the sample object at at least one measuring location of each of the heating sections of the heating furnace;

calculating heating characteristic value for each measuring point at each measuring location based on the measured temperature of the measuring point as well as heating temperature and heating time at each measuring location;

modifying the heating condition by changing either one of or both of the heating temperature and the heating time of at least one of the heating sections;

simulating temperature of each measuring point of the object at each measuring location of the heating furnace under the modified heating condition by using the corresponding heating characteristic values based on a basic equation for heating;

determining that the modified heating condition is appropriate for satisfying the required temperature profile when a temperature profile developed from the simulated temperature meets said required conditions, and

re-modifying the heating condition when the developed temperature profile does not meet said required conditions, and repeating the above procedures until the developed temperature profile meets the required conditions,

wherein said heating characteristic value is an m-value defined by:

$$m = \frac{1}{t} \ln\left[\frac{Ta - Tint}{Ta - Ts}\right]$$

wherein ln is natural logarithm, Ta is heating temperature of the measuring location of the heating furnace, Tint is initial temperature of the measuring point of the object at the measuring location, Ts is achieved temperature when the object is heated at the measuring location, and t is heating time at the measuring location.

13. A method according to claim 11, wherein said heating furnace is either one of reflow furnace, heat treatment furnace, sintering furnace, baking oven, melting furnace, or incinerating equipment.

14. A method of thermal analysis for determining appropriate heating condition for heating an object comprising a circuit substrate having printed solder thereon while the object is transferred in a heating furnace having a plurality of heating sections, forming a preheat stage and a reflow stage in accordance with a required temperature profile corresponding to predetermined required conditions for heating the object, wherein said method comprising steps of:

determining a sample object to be heated and heating condition of each heating section of the heating furnace;

determining required conditions for heating the object in both of the preheat stage and the reflow stage;

heating the sample object, and measuring temperature of at least one measuring point of the sample object at at least one measuring location of each of the heating sections of the heating furnace;

calculating heating characteristic value for each measuring point at each measuring location based on measured temperature of the measuring point as well as heating temperature and heating time at each measuring location;

modifying the heating condition by changing either one of or both of the heating temperature and the heating time of at least one of the heating sections;

simulating temperature of each measuring point of the object at each measuring location of the heating furnace under the modified heating condition by using the corresponding heating characteristic values based on a basic equa-

tion for heating;

determining that the modified heating condition is appropriate for satisfying the required temperature profile when a temperature profile developed from the simulated temperature meets said required conditions of both of the preheat stage and the reflow stage, and

re-modifying the heating condition when the developed temperature profile does not meet said required conditions of the preheat stage or the reflow stage, and repeating the above procedures until the developed temperature profile meets the required conditions,

wherein said heating characteristic value is an m-value defined by:

$$m = \frac{1}{t} \ln\left[\frac{Ta - Tint}{Ta - Ts}\right]$$

wherein ln is natural logarithm, Ta is heating temperature of the measuring location of the heating furnace, Tint is initial temperature of the measuring point of the object at the measuring location, Ts is achieved temperature when the object is heated at the measuring location, and t is heating time at the measuring location.

15. A method according to claim 14, wherein the method further comprises steps of:

verifying the heating condition which has met the predetermined required conditions through simulation by actually heating the sample object under the same heating condition and measuring temperature at each measuring point of the sample object at each measuring location of said heating furnace, before determining that such heating condition is appropriate for satisfying the required temperature profile;

determining that the verified heating condition is appropriate for satisfying the required temperature profile when a temperature profile developed at the verification step meets the required conditions, and

re-calculating the heating characteristic value for each measuring point at each measuring location based on the results of the verification step when the developed temperature profile at the verification step does not meet the required conditions, and repeating the above procedures until the developed temperature profile meets the required conditions.

16. A method according to claim 11, wherein the basic equation for heating is defined by:

$Ts=Ta-(Ta-Tint)\,e^{-m\cdot t}$

wherein Ta is heating temperature of the measuring location of the heating furnace, Tint is initial temperature of the measuring point of the object at the measuring location, Ts is achieved temperature when the object is heated at the measuring location, t is heating time at the measuring location, m is the corresponding heating characteristic value, and e is the base of natural logarithms.

17. A method according to claim 11, wherein said required conditions for heating the object includes either one of, or any combination of:

(a) targeted heating temperature and heating time for keeping the object at a certain temperature for a certain length of time so as to achieve the purpose of heating;

(b) required upper end temperature that the object needs to achieve during heating;

(c) maximum temperature, which is the temperature the object should not go over for sustaining its function;

(d) allowable limited temperature and time that the object may endure during heating process;

(e) preheat temperature and time required for heating the object prior to heating for the ultimate purpose, and

(f) allowable temperature variation among a plurality of measuring points of the object.

18. A program for making a computer to process steps of determining appropriate heating condition of a heating furnace having a plurality of heating sections for heating an object in accordance with a required temperature profile corresponding to predetermined required conditions for heating the object, said steps comprising:

obtaining heating characteristic value of at least one measuring location of each of said plurality of heating sections calculated from heating temperature and heating time at said measuring location as well as measured temperature of at least one measuring point of the object when the object is heated under certain heating condition at said measuring location,

electing one measuring point which has achieved the highest temperature during the heating among all the measuring points, and confirming whether temperature of the elected measuring point is not over the upper limit of the required conditions (confirmation step A);

when temperature of the elected measuring point is over the required conditions at the confirmation step A, modifying the heating condition by lowering the heating temperature based on a predetermined rule and simulating temperature at each measuring point under the modified heating condition by using the corresponding heating characteristic value, and repeating the above procedures from the confirmation step A;

when temperature of the elected measuring point is not over the required conditions at the confirmation step A, confirming whether or not the elected measuring point meets heating time of the required conditions (confirmation step B);

when the heating time of the elected measuring point falls short of the required conditions at the confirmation step B, modifying the heating condition by raising the heating temperature based on a predetermined rule or by lengthening the heating time based on a predetermined rule and simulating temperature for each measuring point under the modified heating condition by using said corresponding heating characteristic value, and repeating the above procedures from the confirmation step A;

when the heating time of the elected measuring point goes over the required conditions at the confirmation step B, modifying the heating condition by lowering the heating temperature based on a predetermined rule or by shortening the heating time based on a predetermined rule and simulating temperature for each measuring point under the modified heating condition by using the corresponding heating characteristic value, and repeating the above procedures from the confirmation step A;

when the heating time of the elected measuring point meet the required conditions at the confirmation step B, confirming whether or not all the other measuring points meet the required conditions (confirmation step C);

when any one of the measuring points does not meet the required conditions at the confirmation step C, modifying the heating condition by lengthening the heating time based on a predetermined rule or by raising the heating tem-

perature based on a predetermined rule and simulating temperature for each measuring point under the modified heating condition by using the corresponding heating characteristic value, and repeating the above procedures from the confirmation step A;

when all the measuring points meet the required conditions at the confirmation step C, determining that such heating condition is appropriate for satisfying the required temperature profile,

wherein the program further includes a logic of making a judgment that determining appropriate heating condition for heating the object in accordance with the required temperature profile is impossible when number of repeating procedures in a closed loop at any of the confirmation steps A-C exceeds a predetermined times.

19. A program for making a computer to process steps of determining appropriate heating condition of a heating furnace having a plurality of heating sections for heating an object in accordance with a required temperature profile corresponding to predetermined required conditions for heating the object, said steps comprising:

obtaining heating characteristic value of at least one measuring location of each of said plurality of heating sections calculated from heating temperature and heating time at said measuring location as well as measured temperature of at least one measuring point of the object when the object is heated under certain heating condition at said measuring location,

electing one measuring point, as a critical measuring point, which has achieved the lowest temperature during the heating among all the measuring points,

detecting heating condition of each of the heating sections which may make said critical measuring point to satisfy both of the required upper end temperature that the object needs to achieve and the maximum temperature that the object should no go over, by simulating temperature of the critical measuring point by using the corresponding heating characteristic value for each of the measuring locations based on a predetermined algorithm,

confirming whether any of the detected heating conditions at the detecting step meet targeted heating temperature and heating time that the object needs to clear for fulfilling the purpose of heating (confirmation step D);

when none of the detected heating conditions meet the targeted heating temperature and heating time at the confirmation step D, modifying the heating condition by lengthening the heating time based on a predetermined rule and simulating temperature at each measuring point under the modified heating condition by using the corresponding heating characteristic value, and repeating the above procedures from the step of electing the critical measuring point;

when any of the detected heating conditions meet the targeted heating temperature and heating time at the confirmation step D, confirming whether such detected heating condition(s) meet other required conditions of allowable limited temperature and time that the object may endure during heating (confirmation step E);

when none of the detected heating condition(s) meet the allowable limited temperature and time at the confirmation step E, modifying the heating condition by shortening the heating time based on a predetermined rule and simulating temperature at each measuring point under the modified heating condition by using the corresponding heating characteristic value, and repeating the above procedures from the step of electing the critical measuring point;

when any one of the detected heating condition(s) meet the allowable limited temperature and time at the confirmation step E, temporarily electing one detected heating condition that has cleared the allowable limited temperature and time requirement by the shortest time among all the detected heating condition(s) as the appropriate heating condition for satisfying the required temperature profile;

confirming whether all the other measuring points meet the required conditions by simulating temperatures under the temporarily elected heating condition by using the corresponding heating characteristic values of the other measuring points (confirmation step F);

when none of the measuring points meet the required conditions at the confirmation step F, modifying the temporarily elected heating condition by shortening heating time based on a predetermined rule and simulating temperature of each measuring point under the modified heating condition by using the corresponding heating characteristic value, and repeating the above procedures from the step of electing the critical measuring point, and

when all the measuring points meet the required conditions at the confirmation step F, determining that the temporarily elected heating condition is appropriate for satisfying the required temperature profile,

wherein when none of heating conditions for the critical measuring point could meet the targeted heating temperature and time requirement at the confirmation step D during the course of the repeated procedures after it was found at the confirmation step F that none of the measuring points meet the required conditions of the second heating stage, and modification of the heating condition was made by shortening heating time, the program further includes a logic of determining approximately appropriate heating condition by lengthening the heating time of the latest temporarily elected heating condition based on a predetermined rule.

20. A program for making a computer to process steps of determining appropriate heating condition of a heating furnace having a plurality of heating sections forming a first and a second heating stages for heating an object in accordance with a required temperature profile corresponding to predetermined required conditions for each of the first and the second stages, said steps comprising:

obtaining heating characteristic value for at least one measuring location of each of said plurality of heating sections calculated from heating temperature and heating time at said measuring location as well as measured temperature of at least one measuring point of the object when the object is heated under certain heating condition at the measuring location,

electing one measuring point which has achieved the highest temperature during heating at the first heating stage among all the measuring points, and confirming whether temperature of the elected measuring point is not over the upper limit of the required conditions (confirmation step A);

when temperature of the elected measuring point is over the required conditions of the first heating stage at the confirmation step A, modifying the heating condition by lowering the heating temperature based on a predetermined rule and simulating temperature at each measuring point under the modified heating condition by using the corresponding heating characteristic value, and repeating the above procedures from the confirmation step A;

when temperature of the elected measuring point is not over the required conditions of the first heating stage at the confirmation step A, confirming

whether or not the elected measuring point meets heating time of the required conditions of the first heating stage (confirmation step B);

when the heating time of the elected measuring point falls short of the required conditions of the first heating stage at the confirmation step B, modifying the heating condition by raising the heating temperature based on a predetermined rule or by lengthening the heating time based on a predetermined rule and simulating temperature for each measuring point under the modified heating condition by using the corresponding heating characteristic value, and repeating the above procedures from the confirmation step A;

when the heating time of the elected measuring point goes over the required conditions of the first heating stage at the confirmation step B, modifying the heating condition of the first heating stage by lowering the heating temperature based on a predetermined rule or by shortening the heating time based on a predetermined rule and simulating temperature for each measuring point under the modified heating condition by using the corresponding heating characteristic value, and repeating the above procedures from the confirmation step A;

when the heating time of the elected measuring point meet the required conditions of the first heating stage at the confirmation step B, confirming whether or not all the other measuring points meet the required conditions of the first heating stage (confirmation step C);

when any one of the measuring points does not meet the required conditions of the first heating stage at the confirmation step C, modifying the heating condition by lengthening the heating time of the first heating stage based on a predetermined rule or by raising the heating temperature of the first heating stage based on a predetermined rule and simulating temperature for each measuring point under the modified heating condition by using the corresponding heating characteristic value, and repeating the above procedures from the confirmation step A;

when all the measuring points meet the required conditions for the first heating stage at the confirmation step C, electing one measuring point, as a critical measuring point, which has achieved the lowest temperature at the second heating stage during heating among all the measuring points;

detecting heating condition of each of the heating sections in the second heating stage which may make said critical measuring point to satisfy both of the

required upper end temperature that the object needs to achieve and the maximum temperature that the object should no go over, by simulating temperature of the critical measuring point by using the corresponding heating characteristic value for each of the measuring locations in the second heating stage based on a predetermined algorithm,

confirming whether or not any of the detected heating conditions at the detecting step meet targeted heating temperature and heating time that the object needs to clear for fulfilling the purpose of heating (confirmation step D);

when none of the detected heating conditions meet the targeted heating temperature and heating time at the confirmation step D, modifying the heating condition by lengthening the heating time based on a predetermined rule and simulating temperature at each measuring point under the modified heating condition by using the corresponding heating characteristic value, and repeating the above procedures either from the step of electing the critical measuring point or from the confirmation step A;

when any one of the detected heating conditions meet the targeted heating temperature and heating time at the confirmation step D, confirming whether such detected heating condition(s) meet other required conditions of allowable limited temperature and time that the object may endure during heating (confirmation step E);

when none of the detected heating condition(s) meet the allowable limited temperature and time at the confirmation step E, modifying the heating condition by shortening the heating time based on a predetermined rule and simulating temperature at each measuring point under the modified heating condition by using the corresponding heating characteristic value, and repeating the above procedures either from the step of electing the critical measuring point or from the confirmation step A;

when any one of the detected heating condition (s) meet the allowable limited temperature and time at the confirmation step E, temporarily electing one detected heating condition that has cleared the allowable limited temperature and time requirement by the shortest time among all the detected heating condition(s) as the appropriate heating condition for satisfying the required temperature profile;

confirming whether all the other measuring points meet the required condi-

tions of the second heating stage by simulating temperatures under the temporarily elected heating condition by using the corresponding heating characteristic values of the other measuring points (confirmation step F);

when any of the measuring points do not meet the required conditions of the second heating stage at the confirmation step F, modifying the temporarily elected heating condition by shortening heating time based on a predetermined rule and simulating temperature of each measuring point under the modified heating condition by using the corresponding heating characteristic value, and repeating the above procedures either from the step of electing the critical measuring point or from the confirmation step A; and

when all the measuring points meet the required conditions for the second heating stage at the confirmation step F, determining that the temporarily elected heating condition is appropriate for satisfying the required temperature profile.

21. A program according to claim 20, wherein when none of heating conditions for the critical measuring point could meet the targeted heating temperature and time requirement at the confirmation step D during the course of the repeated procedures after it was found at the confirmation step F that none of the measuring points meet the required conditions of the second heating stage, and modification of the heating condition was made by shortening heating time, the program further includes a logic of determining approximately appropriate heating condition by lengthening the heating time of the latest temporarily elected heating condition based on a predetermined rule.

22. A program according to claim 20, wherein the program further includes a logic of making a judgment that determining appropriate heating condition for heating the object in accordance with the required temperature profile is impossible when number of repeating procedures in a closed loop at any of the confirmation steps A-F exceeds a predetermined times.

23. A program according to claim 20, wherein said heating characteristic value is an m-value defined by:

$$m = \frac{1}{t} \ln\left[\frac{Ta - Tint}{Ta - Ts}\right]$$

wherein In is natural logarithm, Ta is heating temperature of the measuring location of the heating furnace, Tint is initial temperature of the measuring point of the object at the measuring location, Ts is achieved temperature when the object is heated at the measuring location, and t is heating time at the measuring location, and simulating temperature of each of measuring point using the corresponding heating characteristic value is made based on a following basic equation for heating:

$Ts=Ta-(Ta-Tint)\,e^{-m\cdot t}$

wherein e in the equation represents the base of natural logarithms.

24. A program according to claim 20, wherein the predetermined rule for lowering the heating temperature when temperature of the elected measuring point is over the required conditions at the confirmation step A is either lowering the heating temperature down to the upper end temperature of the allowable range of the required heating conditions, or lowering the heating temperature by an amount obtained by multiplying a certain ratio to a temperature difference identified between the measured or simulated temperature and the upper end temperature of the allowable range.

25. A program according to claim 20, wherein the predetermined rule for raising or lowering the heating temperature when heating time of the elected measuring point falls short of or goes over the required conditions at the confirmation step B is either raising or lowering the heating temperature of the particular heating section(s) by a predetermined amount, which particular heating section(s) are those located in advance of the heating section where temperature of the elected measuring point reaches the allowable range of the required conditions.

26. A program according to claim 20, wherein the predetermined rule for lengthening heating time when any one of the measuring points does not meet the required conditions at the confirmation step C is to multiply preceding transfer speed of the object with a ratio closest to 1 among the ratios of required heating time versus measured or simulated heating time for each of the measuring points which failed to meet the required conditions, or to divide the preceding heating time by the same ratio.

27. A program according to claim 20, wherein the predetermined algorithm for detecting heating conditions for making the critical measuring point to satisfy both of the required upper end temperature and the maximum temperature is configured by the steps of:

creating combinations of heating condition of at least two heating sections by raising respective heating temperatures independently by every predetermined amount from the initial temperature of the object at the beginning of the heating section up to a predetermined upper limit temperature defined by the heating furnace;

simulating temperature of the critical measuring point under each of the created combinations of the heating condition, and developing temperature profiles corresponding to each of the combinations of the heating condition; and

detecting any of the combinations of the heating condition which may make the corresponding simulated temperature to locate inside a zone defined by said at least two heating sections, which zone is surrounded by an upper boundary and a lower boundary, wherein the upper boundary comprising an temperature increase line between a point H of an initial temperature of the preceding heating section and a point E of the maximum temperature at the end of the same heating section as well as a line of the maximum temperature between said point E and a point G at the end of said at least two heating sections, while the lower boundary comprising a line between said point H and a point F of the required upper end temperature at the end of said at least two heating sections.

28. A program according to claim 20, wherein the predetermined rule for lengthening the heating time when none of the heating conditions meet the required time conditions at the confirmation step D is to multiply preceding transfer speed of the object with a ratio closest to 1 among the ratios of the heating time at the targeted heating temperature versus corresponding simulated time for each of the measuring points which failed to meet the required conditions, or to divide the preceding heating time by the same ratio.

29. A program according to claim 20, wherein the predetermined rule for shortening the heating time when none of the heating conditions meet the required time conditions at the confirmation step E is to multiply preceding transfer speed of the object with a ratio closest to 1 among the ratios of heating time at the al-

lowable limited temperature versus corresponding simulated time for each of the measuring points which failed to meet the required conditions, or to divide the preceding heating time by the same ratio.

30. A program according to claim 20, wherein the predetermined rule for shortening the heating time when any of the heating conditions do not meet the required conditions at the confirmation step F is to multiply preceding transfer speed of the object with a ratio closest to 1 among the ratios of the heating time at the targeted heating temperature versus corresponding simulated time, or among the ratios of the heating time at the allowable limited temperature versus corresponding simulated time for each of the measuring points which failed to meet the required condition, or to divide the preceding heating time by the same ratio.

31. A program according to claim 20, wherein in addition to overall required conditions for heating the object which are to be applied equally to any part of the object, individual required conditions are separately determined which are to be applied to corresponding each of the measuring points of the object individually, and the program further includes a logic for making a judgment that even if the heating condition does not meet some requirements of the overall required conditions at some measuring points, such heating conditions are deemed appropriate as far as said individual required conditions to be applied to those particular measuring points are satisfied.

32. A computer readable recording medium recording a program for making a computer to process steps of determining appropriate heating condition for heating an object in accordance with a required temperature profile corresponding to required conditions for heating the object, wherein said program is defined by claim 20.

33. An apparatus for performing thermal analysis to be used for heating an object in a heating furnace, comprising a input means, a memory and a processor,

wherein said input means obtains information of heating temperature and heating time of the heating furnace and temperature of the object,

said memory stores a logic for calculating heating characteristic value, and

a basic equation for heating or a logic for calculating temperature of the object to be heated by using said heating characteristic value as well as the heating temperature and heating time, and

said processor calculates either said heating characteristic value or temperature of the object corresponding to the heating temperature and the heating time, by using said logics and said basic equation for heating stored in the memory.

34. An apparatus according to claim 33, wherein the apparatus further comprises a reading means for reading recording medium, wherein the processor determines appropriate heating condition including heating temperature and heating time, which may satisfy the required conditions of the object to be heated, by using the required conditions for heating the object obtained by the input means, algorithm that the reading means obtained by reading the recording medium, and the heating characteristic value calculated by the processor.

35. An apparatus according to claim 33, wherein said heating characteristic value is an m-value defined by:

$$m = \frac{1}{t} \ln\left[\frac{Ta - Tint}{Ta - Ts}\right]$$

wherein ln is natural logarithm, Ta is the heating temperature, Tint is initial temperature of the object, Ts is achieved temperature when the object is heated, and t is the heating time.

36. An apparatus according to claim 33, wherein said basic equation for heating is defined by:

$Ts = Ta - (Ta - Tint)\, e^{-m \cdot t}$

wherein Ta is the heating temperature, Tint is initial temperature of the object, Ts is achieved temperature when the object is heated, t is the heating time, e is the base of natural logarithms, and m is the heating characteristic value.

37. A heat controller for determining appropriate heating condition including heating temperature and heating time for each of heating sections structured in a heating furnace, and for controlling the heating furnace based on such determined appropriate heating condition so as to heat an object in accordance with a

required temperature profile corresponding to required conditions for heating the object, said controller comprising an input means, an output means, a memory, a processor and a reading means for reading recording media,

wherein the controller controls the heating furnace by reading recording medium defined by claim 32.

38. A heating furnace for heating an object introduced into the furnace in accordance with a required temperature profile corresponding to required conditions for heating the object, said heating furnace comprising at least one heating section, a heat source provided to each of the heating sections for heating the object, and a heat controller capable of controlling heating condition for each of the heating sections,

wherein said heat controller is defined by claim 37.

39. A heating furnace according to claim 38, wherein said heating furnace is either one of reflow furnace, heat treatment furnace, sintering furnace, baking oven, melting furnace, and incinerating equipment.

40. A method of thermal analysis, wherein cooling characteristic of at least one measuring point of an object at one measuring location of a cooling equipment is determined as a single invariable by using temperature measured at said at least one measuring point of the object as well as cooling temperature and cooling time at the at least one measuring location of the cooling apparatus, which cooling characteristic represents physical characteristics of both of the cooling equipment and the object to be cooled, wherein appropriate cooling condition of a cooling equipment for cooling the object in accordance with a required temperature profile is determined by using the determined invariables.